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Ingrid REINECK et al.	)	Group Art Unit: 3722
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Application No.: 09/349,106	)	Examiner: Unassigned
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Filed: July 8, 2000	)	
	)	
For: COATED GROOVING OR PARTING INSERT	)	

CLAIM FOR CONVENTION PRIORITY

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed:

Swedish Patent Application No. 9802488-8

Filed: July 9, 1998

In support of this claim, enclosed is certified copy of said prior foreign application. Said prior foreign application was referred to in the oath or declaration. Acknowledgment of receipt of the certified copy is requested.

Respectfully submitted,

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Date: February 3, 2000

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PATENT- OCH REGISTRERINGSVERKET
Patentavdelningen

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This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.

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For the Patent- and Registration Office

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Coated grooving or parting insert

The present invention relates to a coated cutting tool (cemented carbide insert) useful for grooving or particularly parting of steel components such as steel or stainless steel tubes and bars.

On parting of steel or stainless steel tubes or bars, the cutting edge achieves a high temperature with the consequence that the work piece material is welded onto the cutting edge with coating flaking as a failure mechanism in combination with tear-out of small cemented carbide chips. On the other hand, for grooving of the same materials, a high coating wear resistance in combination with a stiff substrate material is required. Finding a cutting tool material that fulfils both these requirements is a challenge.

So far it has been very difficult to improve all tool properties simultaneously. Commercial cemented carbide grades have therefore been optimised with respect to one or few of the wear types and hence to specific application areas.

Swedish patent application 9602413-8 discloses a coated cutting insert particularly suited for wet turning of toughness demanding stainless steel components. The inserts are characterised by a cemented carbide body consisting of WC-Co and cubic carbides coated by one layer of $TiC_xN_yO_z$ with columnar grains, one layer of smooth, fine grained κ-Al_2O_3, and preferably an outer layer of TiN.

Swedish patent application 9504304-8 discloses a coated cutting insert particularly useful for wet and dry milling of low and medium alloyed steels. The insert is characterised by a cemented carbide substrate consisting of Co-WC and cubic carbides, a coating including a layer of $TiC_xN_yO_z$ with columnar grains, a layer of smooth, fine grained κ-Al_2O_3 and preferably an outer layer of TiN.

It has now been found that a combination of the cemented carbide substrates, coatings and insert styles described in the above patent applications gives rise to excellent cutting performance in grooving or, in particular, parting of steel or stainless steel. A cemented carbide substrate coated with a relatively thin coating in accordance with the above mentioned

patent application, 9602413-8, has surprisingly been found to have an outstanding performance in parting of easy stainless steel, such as machineability improved 304L, as well as in more wear resistance demanding materials such as high alloyed steels. The flaking resistance, which is an important factor in parting operations, is greatly improved.

Fig 1 shows in 1800X a cross section of an insert according to the invention.

A cutting tool insert according to the invention useful for parting or grooving of steel and stainless steel consists of a cemented carbide substrate with a highly W-alloyed binder phase and with a well balanced chemical composition and grain size of the WC, a columnar $TiC_xN_yO_z$-layer which layer thickness should be kept as low as possible, a κ-Al_2O_3-layer, a TiN-layer and optionally followed by smoothening the cutting edges by brushing the edges with e.g. a SiC based brush. The beneficial properties have surprisingly been achieved with a relatively thin coating.

The cobalt binder phase is highly alloyed with W. The content of W in the binder phase can be expressed as the CW-ratio= M_s / (wt% Co $\cdot$ 0.0161), where M_s is the measured saturation magnetisation of the cemented carbide substrate in kA/m and wt% Co is the weight percentage of Co in the cemented carbide. The CW-value is a function of the W content in the Co binder phase. A low CW-value corresponds to a high W-content in the binder phase. According to the present invention improved cutting performance is achieved if the cemented carbide substrate has a CW-ratio of 0.78-0.93.

According to the present invention a parting tool insert is provided with a cemented carbide substrate with a composition of 6-15 wt% Co, preferably 9-12 wt% Co, most preferably 10-11 wt% Co, 0.2-1.8 wt% cubic carbides, preferably 0.4-1.8 wt% cubic carbides, most preferably 0.5-1.7 wt% cubic carbides of the metals Ta, Nb and Ti and balance WC. The cemented carbide may also contain other carbides from elements from group IVb, Vb or VIb of the periodic table. The content of Ti is preferably on a level corresponding to a technical impurity. The preferred average grain size of the WC depend on the binder phase content. At the preferred composition of 10-11 wt-% Co, the preferred grain size is 1.5-2 µm, most preferably about 1.7 µm. The CW-

ratio shall be 0.78-0.93, preferably 0.80-0.91, and most preferably 0.82-0.90. The cemented carbide may contain small amounts, <1 volume %, of η-phase (M_6C), without any detrimental effect. From the CW-value it follows that no free graphite is allowed in the cemented carbide substrate according to the present embodiment.

The coating comprises

A. a first (innermost) layer of $TiC_xN_yO_z$ with x+y+z=1, preferably y>x and z<0.2, most preferably y>0.8 and z=0, with equiaxed grains with size <0.5 μm and a total thickness <1.5 μm but >0.1 μm, preferably 0.1-0.6 μm.

B. a layer of $TiC_xN_yO_z$ with x+y+z=1, preferably with z=0, x>0.3 and y>0.3, most preferably x>0.5, with a thickness of 0.4-3.9 μm, preferably 1.5-3.0 μm with columnar grains and with an average diameter of <5 μm, preferably 0.1-2 μm

C. the total thickness of the layers according to A + B is 0.5-4 μm, preferably 1.5-3.5 μm. Preferably, the layer according to A is thinner than that described by B.

D. a layer of a smooth, fine-grained (grain size about 0.5-2 μm) Al_2O_3 consisting essentially of the κ-phase. However, the layer may contain small amounts, 1-3 vol-%, of the θ- or the α-phases as determined by XRD-measurement. The Al_2O_3-layer has a thickness of 0.5-5.5 μm, preferably 0.5-3 μm. Preferably, this Al_2O_3-layer is followed by a further layer (<1 μm, preferably 0.1-0.5 μm thick) of TiN, but the Al_2O_3 layer can be the outermost layer. This outermost layer, Al_2O_3 or TiN, has a surface roughness R_{max}<0.4 μm over a length of 10 μm. The TiN-layer, if present, is preferably removed along the cutting edge.

E. the total thickness of the layers according to A + B + D is 2-6 μm, preferably 3-5 μm.

According to the method of the invention a WC-Co-based cemented carbide substrate is made with a highly W-alloyed binder phase with a CW-ratio of 0.78-0.93, preferably 0.80-0.91, and most preferably 0.82-0.90, a content of cubic carbides of 0.2-1.8 wt%, preferably 0.4-1.8 wt%, most preferably 0.5-1.7 wt% of the metals Ta, Nb and Ti, with 6-15 wt% Co, preferably 9-12 wt% Co, most preferably 10-11 wt% Co at which Co-content the WC grain size 1.5-2 μm, most preferably about 1.7 μm. The body is coated with:

A. a first (innermost) layer of $TiC_xN_yO_z$ with x+y+z=1, preferably y>x and z<0.2, most preferably y>0.8 and z=0, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm, preferably >0.1 µm, preferably 0.1-0.6 µm, using known CVD-methods.

B. a layer of $TiC_xN_yO_z$ with x+y+z=1, preferably with z=0, x>0.3 and y>0.3, most preferably x>0.5, with a thickness of 0.4-3.9 µm, preferably 1.5-3.0 µm, with columnar grains and with an average diameter of about <5 µm, preferably 0.1-2 µm, using preferably MTCVD-technique (using acetonitrile as the carbon and nitrogen source for forming the layer in the temperature range of 700-900 ^{O}C). The exact conditions, however, depend to a certain extent on the design of the equipment used.

C. the total thickness of the layers according to A + B is 0.5-4 µm, preferably 1.5-3.5 µm. Preferably, the layer according to A is thinner than that described by B.

D. a layer of a smooth, fine-grained (grain size about 0.5-2 µm) Al_2O_3 consisting essentially of the κ-phase. The Al_2O_3-layer has a thickness of 0.5-5.5 µm, preferably 0.5-3 µm. Preferably, this Al_2O_3-layer is followed by a further layer (<1 µm, preferably 0.1-0.5 µm thick) of TiN, but the Al_2O_3 layer can be the outermost layer. This outermost layer, Al_2O_3 or TiN, has a surface roughness R_{max}<0.4 µm over a length of 10 µm. The smooth coating surface can be obtained by a gentle wet-blasting the coating surface with fine grained (400-150 mesh) alumina powder or by brushing (preferably used when TiN top layer is present) the edges with brushes based on SiC as disclosed in Swedish patent application 9402543-4. The TiN-layer, if present, is preferably removed along the cutting edge.

E. the total thickness of the layers according to A + B + D is 2-6 µm, preferably 3-5 µm.

Example 1

A. A cemented carbide parting tool insert in style N151.2-300-5E with the composition 10.5 wt-% Co, 1.16 wt-% Ta, 0.28 wt-% Nb and balance WC, with a binder phase highly alloyed with W corresponding to a CW-ratio of 0.87, was coated with an innermost 0.5 µm equiaxed $TiC_{0.05}N_{0.95}$-layer with a high nitrogen content, corresponding to an estimated C/N ratio of 0.05,

followed by a 2.2 µm thick layer of columnar $TiC_{0.54}N_{0.46}$ deposited using MT-CVD technique. In subsequent steps during the same coating process a 1.5 µm layer of Al_2O_3 consisting of pure κ-phase according to procedure disclosed in EP-A-523 021. A thin, 0.5 µm, TiN layer was deposited, during the same cycle, on top of the Al_2O_3-layer. Hence, the total thickness of all layers is 4.7 µm. The coated insert was brushed by a SiC containing nylon straw brush after coating, removing the outer TiN layer on the edge.

B. A cemented carbide parting tool insert in style N151.2-300-5E with the composition of 8.0 wt-% Co, no cubic carbides, balance WC and a CW-ratio of 0.94. The insert was coated with an innermost 0.5 µm equiaxed TiCN-layer A 1.5 µm, TiN layer was deposited, during the same cycle, on top of the TiCN-layer. No post treatment was applied.

C. A cemented carbide parting tool insert in style N151.2-300-5E with the composition of 8.0 wt-% Co, no cubic carbides, balance WC and a CW-ratio of 0.94. The insert was coated with an innermost 0.5 µm equiaxed TiCN-layer with a high nitrogen content, corresponding to an estimated C/N ratio of 0.05, followed by a 4.0 µm thick layer of columnar TiCN deposited using MT-CVD technique. In subsequent steps during the same coating process a 1.0 µm layer of Al_2O_3 consisting of pure κ phase according to procedure disclosed in EP-A-523 021. A thin, 0.5 µm, TiN layer was deposited, during the same cycle, on top of the Al_2O_3-layer. The coated insert was brushed by a SiC containing nylon straw brush after coating, removing the outer TiN layer on the edge.

D. A competitive cemented carbide parting tool insert in style similar to N151.2-300-5E from an external leading cemented carbide producer was selected for comparison. The carbide had a composition of 11.0 wt-% Co, 7.1 wt-% TiC, 12.1 wt-% TaC, 1.3 wt-% NbC, balance WC and a CW-ratio of 0.80. The insert had a coating consisting of 1.1 µm TiN and, outermost, 0.3 µm TiCN. Examination in light optical microscope revealed no edge treatment subsequent to coating.

Inserts from A, B and C were compared in a flaking test comprising a facing operation in austenitic stainless steel

SanMac 304L. Feed 0.15 mm/rev, speed 130 m/min and depth of cut varying between 0-2.5 mm.

Insert	Number of cuts before extensive flaking
A (acc. to invention)	10
B (outside invention)	5
C (outside invention)	1
D (external grade)	1

Example 2

Inserts A, B, C and D from above were tested in a parting test in stainless steel SS2343 o 12mm bar stainless steel.

The rotating speed was 1800 rpm, feed varying 0,15-0,02 mm/rev (low feed rate close to centre of bar).

The wear mechanism was flaking combined with nose cracking.

Insert	Number of components
A (acc. to invent.)	380
B (outside invention)	180
C (outside invention)	200
D (external grade)	200

Example 3

Inserts A (insert style N151.2-400-4E) and D were tested at an end users machine shop in parting of a stainless steel tube (SS2343, OD 27mm, ID 25mm) with feed 0.05 mm/rev and speed 150 m/min.

Insert D failed due to major chipping of the cutting edge while a very small chipping was seen on insert A.

Insert	Number of components
A (acc. to invention)	324
D (external grade)	108

Example 4

Inserts A and D were tested at an end users machine shop in parting to centre of an annealed high alloy steel SS2242 with feed 0.15 mm/rev and speed 100 m/min.

Insert D failed due to cracking in the corners while a very small deformation in the corners was seen on insert A.

Insert	Number of components
A (acc. to invention)	400
D (external grade)	150

Example 5

Inserts A (insert style N151.2-400-4E) and D were tested at an end users machine shop in parting of a steel bar (SS2225, OD 50mm) with feed 0.06-0,14 mm/rev and speed 180 m/min.

Insert D failed due to chipping of the cutting edge while even flank wear was seen on insert A.

Insert	Number of components
A (acc. to invention)	300
D (external grade)	150

Claims

1. A cutting tool insert particularly for parting of steel and stainless steel comprising a cemented carbide body and a coating c h a r a c t e r i s e d in that said cemented carbide body consists of WC, 6-15, preferably 9-12, wt-% Co and 0.2-1.8 wt-% cubic carbides of Ti, Ta and/or Nb and a highly W-alloyed binder phase with a CW-ratio of 0.78-0.93, preferably 0.80-0.91 and in that said coating comprises

- a first (innermost) layer of $TiC_xN_yO_z$ with x+y+z=1, preferably y>x and z<0.2 with a thickness of 0.1-1.5 µm, preferably 0.1-0.6 µm and with equiaxed grains with size <0.5 µm

- a layer of $TiC_xN_yO_z$ with x+y+z=1, µm preferably with z=0, x>0.3 and y>0.3 with a thickness of 0.4-3.9 µm, preferably 1.5-3.0 µm, with columnar grains with an average diameter of 0.1-5 µm, preferably 0.1-2 µm.

- an outer layer of a smooth, fine-grained (0.5-2 µm) κ-Al_2O_3-layer with a thickness of 0.5-5.5 µm, preferably 0.5-3 µm.

- the total thickness of the innermost $TiC_xN_yO_z$ and the columnar $TiC_xN_yO_z$ layer is 0.5-4 µm, preferably 1.5-3.5 µm.

- the total thickness of all layers is 2.0-6.0 µm, preferably 3.0-5.0 µm.

2. Cutting insert according to any of the preceding claims c h a r a c t e r i s e d in that the outermost layer is a thin 0.1-1 µm TiN-layer.

3. Cutting insert according to claim 2 c h a r a c t e r i s e d in that the outermost TiN-layer has been removed along the cutting edge.

4. Method of making an insert for turning comprising a cemented carbide body and a coating c h a r a c t e r i z e d in that a WC-Co-based cemented carbide body with a highly W-alloyed binder phase with a CW-ratio of 0.78-0.93 is coated with

- a first (innermost) layer of $TiC_xN_yO_z$ with x+y+z=1, preferably y>x and z<0.2 with a thickness of 0.1-1.5 µm, preferably 0.1-0.6 µm and with equiaxed grains with size <0.5 µm using known CVD-methods

- a layer of $TiC_xN_yO_z$ with x+y+z=1, µm preferably with z=0, x>0.3 and y>0.3 with a thickness of 0.4-3.9 µm, preferably 1.5-3.0 µm, with columnar grains with an average diameter of 0.1-5

μm, preferably 0.1-2 μm deposited by MTCVD-technique, using acetonitrile as the carbon and nitrogen source for forming the layer in a preferred temperature range of 850-900 °C.

- a layer of a smooth κ-Al_2O_3 with a thickness of 0.5-5.5 μm, preferably 0.5-3 μm.

- preferably a layer of TiN with a thickness of <1 μm.

- the total thickness of the innermost $TiC_xN_yO_z$ and the columnar $TiC_xN_yO_z$ layer is 0.5-4 μm, preferably 1.5-3.5 μm.

- the total thickness of all layers is 2.0-6.0 μm, preferably 3.0-5.0 μm.

5. Method according to the previous claim c h a r a c t e r i s e d in that said cemented carbide body has a cobalt content of 9-12 wt% and 0.4-1.8 wt% cubic carbides of Ta and Nb.

6. Method according to claim 4 or 5 c h a r a c t e r i s e d in that said cemented carbide body has a cobalt content of 10-11 wt%.

7. Method according to claim 4, 5 or 6 c h a r a c t e r i z e d in a CW-ratio of 0.82-0.90.

8. Method according to any of the claims 4, 5, 6 and 7 c h a r a c t e r i z e d in that the outermost TiN-layer, if present, is removed along the cutting edge.

Abstract

The present invention relates to a coated cutting tool (cemented carbide insert) useful for grooving or particularly parting of steel components such as steel or stainless steel tubes and bars. The insert is characterised by WC-Co-based cemented carbide substrate having a highly W-alloyed Co-binder phase and a relatively thin coating including an inner layer of $TiC_xN_yO_z$ with columnar grains followed by a layer of fine grained κ-Al_2O_3 and a top layer of TiN.

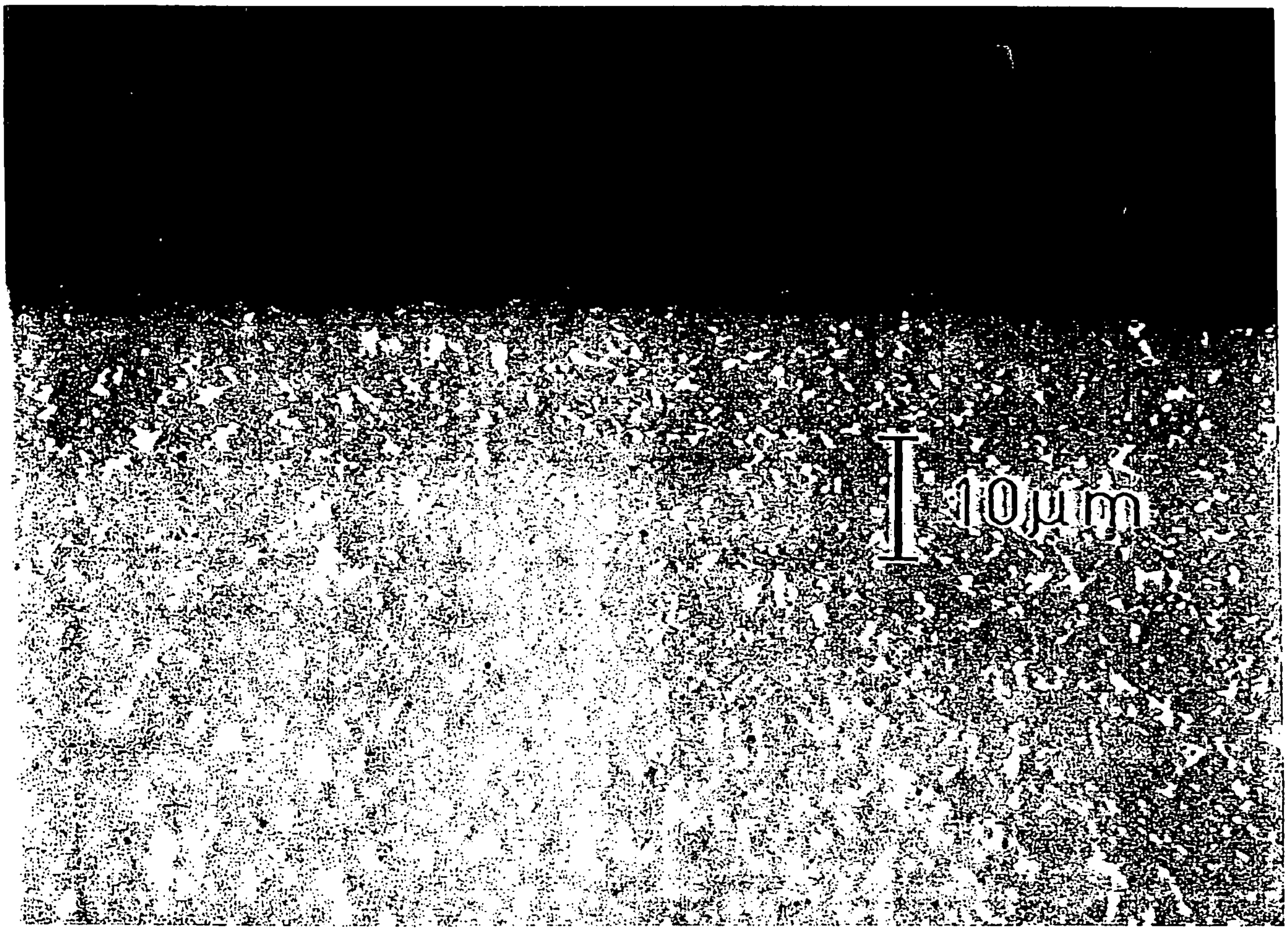

Fig. 1